Cukurova Medical Journal
ÇUKUROVA ÜNİVERSİTESİ TIP FAKÜLTESİ

Cukurova Med J 2025;50(3):579-585
DOI: 10.17826/cumj.1550967

RESEARCH

Exploring vestibular dysfunction in primary hypothyroidism using cervical vestibular evoked myogenic potentials

Primer hipotiroidizmde vestibüler disfonksiyonun servikal vestibüler uyarılmış miyojenik potansiyeller ile değerlendirilmesi

Ayhan Kars[1], Fatma Atalay[2], Kübra Topal[3], Sezai Sacid Anbar[4], Fatma Akyel[5], Korhan Kılıç[6]

[1]Erzincan Binali Yıldırım University, Erzincan, Türkiye
[2]Kastamonu University, Kastamonu, Türkiye
[3]Private Otorhinolaryngology Clinic, Kastamonu, Türkiye
[4]Kastamonu Training and Research Hospital, Kastamonu, Türkiye
[5]Araç State Hospital, Kastamonu, Türkiye
[6]Ataturk University, Erzurum, Türkiye

Abstract

Purpose: This research was conducted to assess cervical vestibular evoked myogenic potential (cVEMP) test responses in patients with primary hypothyroidism without vestibular symptoms.

Materials and Methods: Thirty-one patients diagnosed with primary hypothyroidism and who had not yet started on hormone replacement therapy, together with a 26-member control group, were enrolled in the research. All participants underwent detailed otorhinolaryngological examinations and thyroid function, cVEMP, and audiological tests. cVEMP records were compared between the groups.

Results: Thirty-one patients aged between 21 and 57 years (38.5±9.7) and a control group of 26 healthy volunteers aged between 20 and 52 years (36.1±8.8) were included in the study. Absent VEMP responses were observed in 12 members of the patient group and in three of the control group. Interpeak amplitudes (IPAs) in both ears were significantly lower in the patient group than in the controls. While no significant difference was found between the groups' VEMP threshold values, asymmetry rates in both ears were significantly higher in the patient group.

Conclusion: cVEMP can be usefully employed in the detection of subclinical vestibular dysfunction in hypothyroid patients.

Keywords:. Cervical vestibular evoked myogenic potentials, hypothyroidism, thyroid, vertigo, vestibular system.

Öz

Amaç: Bu çalışma, vestibüler semptomları olmayan primer hipotiroidizmli hastalarda servikal vestibüler uyarılmış miyojenik potansiyel (cVEMP) test yanıtlarını değerlendirmek amacıyla yapıldı.

Gereç ve Yöntem: Primer hipotiroidi tanısı konmuş ve henüz hormon replasman tedavisine başlanmamış 31 hasta ile birlikte 26 kişilik bir kontrol grubu araştırmaya dahil edildi. Tüm katılımcılara ayrıntılı kulak burun boğaz muayeneleri, tiroid fonksiyon testleri, cVEMP testleri ve odyolojik testler yapıldı. Gruplar arasında cVEMP kayıtları karşılaştırıldı.

Bulgular: Çalışmaya yaşları 21-57 (38,5±9,7) arasında değişen 31 hasta ve yaşları 20-52 (36,1±8,8) arasında değişen 26 sağlıklı gönüllüden oluşan kontrol grubu dahil edildi. Hasta grubunda 12, kontrol grubunda ise üç kişide VEMP yanıtının olmadığı gözlendi. Hasta grubunda her iki kulaktaki interpeak amplitüdleri (IPAs) kontrol grubuna kıyasla anlamlı olarak düşüktü. Grupların VEMP eşik değerleri arasında anlamlı bir fark bulunmazken, her iki kulaktaki asimetri oranları hasta grubunda anlamlı olarak daha yüksekti.

Sonuç: Servikal vestibüler uyarılmış miyojenik potansiyeller hipotiroidi hastalarında subklinik vestibüler disfonksiyonun tespitinde faydalı olabilir.

Anahtar kelimeler: Servikal vestibüler uyarılmış miyojenik potansiyeller, hipotiroidizm, tiroid, vertigo, vestibüler sistem.

Address for Correspondence: Ayhan Kars, Erzincan Binali Yıldırım University Faculty of Medicine, Department of Otorhinolaryngology, Head and Neck Surgery, Erzincan, Türkiye E-mail: drakars25@hotmail.com
Received: 17.09.2024 Accepted: 03.06.2025

INTRODUCTION

Vertigo and balance disorders are seen in approximately 15-20% of the global adult population. These may derive from central or peripheral vestibular diseases. The most frequent causes of peripheral vestibular vertigo in clinical ear, nose, and throat practice include benign paroxysmal positional vertigo, vestibular neuronitis, and Meniere's disease. In addition to peripheral vestibular causes, vertigo can also result from neurological and autoimmune disorders and cardiovascular diseases[1]. Metabolic disorders are also regarded as potentially responsible for balance disorders by a number of authors[2].

Hypothyroidism refers to an insufficiency of thyroid hormones (free T3 (triiodothyronine) and free T4 (thyroxine)[3]. Thyroid gland hormones affect the neuromuscular system[4]. Neuromuscular dysfunctions are reported in 20-80% of thyroid diseases[5]. Neurological signs and symptoms can therefore be seen in association with hypothyroidism[4]. Similarly, thyroid hormones have also been described as being of crucial importance to auditory and vestibular system development[6]. Experimental studies have shown that thyroid disorders can affect both the peripheral and central vestibular systems[7]. Thyroid disorders have been reported as a frequent cause of vertigo[1]. Auditory and vestibular abnormalities have been documented in animals that have been rendered hypothyrodic[6]. Vertigo complaints occur in 67% of patients with hypothyroidism[3]. Electrophysiological tests are particularly important in terms of the early detection of neuropathy in patients with hypothyroidism[8].

The vestibular evoked myogenic potential (VEMP) test is a rapid, simple, non-invasive, low-cost, and objective technique employed in the diagnosis of vestibular diseases and that permits the electrophysiological testing of vestibular functions[9-11]. Two VEMP tests are used in clinical practice, cervical VEMP (cVEMP) and ocular VEMP (oVEMP)[11]. oVEMP provides information about utriculo-ocular reflex pathway function, and cVEMP about vestibulocollic reflex pathway function[11,12]. The neural pathway tested using cVEMP begins from the saccule and provides stimulation of the sternocleidomastoid (SCM) muscle through the inferior vestibular nerve, lateral vestibular nucleus, medial vestibulospinal tract, and spinal cord motor neurons[12,13]. Biphasic responses are obtained with the application of acoustic stimuli. Electromyographic activity is recorded through superficial electrodes placed over the SCM muscle[12]. The presence or absence of a record, its structure and symmetry, yield information about peripheral pathologies of the vestibular nerve[1]. VEMP abnormalities have been shown in multiple sclerosis, ankylosing spondylitis, vitamin B12 deficiency, vestibular migraine, and various neurodegenerative disorders[9,10,14]. Neurophysiological tests can be beneficial in the early diagnosis of complications in these diseases[10].

This study was performed in order to investigate vestibular hypofunction at an early stage by examining cVEMP responses in primary hypothyroid patients without vestibular symptoms. The findings may contribute to the existing literature on the use of cVEMP test in detecting subclinical vestibular hypofunction.

MATERIALS AND METHODS

Sample

The Kastamonu University Clinical Research Ethical Committee approved this prospective study under decision no. 2020-KAEK-143-29, dated 28.01.2021. The research was conducted in compliance with the principles of the Declaration of Helsinki. Written informed consent was obtained from all participants after the study protocol had been explained to them.

Patients diagnosed with primary hypothyroidism between February and July 2021 at the Kastamonu Training and Research Hospital Internal Medicine Clinic, Türkiye, and who had not yet started on hormone replacement therapy, together with a control group made up of completely healthy individuals, were included in the study.

Individuals with histories or symptoms of vertigo, with inner or outer ear disease, with histories of otological surgery, using muscle relaxant medications, with pathological audiological tests (pure-tone audiometry and tympanometry), using hearing devices, with histories of neck surgery including thyroidectomy, with neuropsychiatric diseases, with additional conditions (drug, chemical, disease) causing neuropathy, aged over 60 (VEMP responses weaken in the over-60s)[15], or with autoimmune thyroid disease were excluded from the study.

The power analysis was based on the changes in IPA. Using G power software, the power of the study was

calculated as 95.5% for an effect size of 0.93 and an alpha error of 0.05, with 26 patients in each group.

Laboratory measurements

The members of both groups underwent detailed otorhinolaryngological examinations and thyroid function, cVEMP, and audiological (pure-tone audiometry and tympanometry) tests. Pure-tone audiometry tests were conducted using an AD629 device (Interacoustics, Middelfart, Denmark), and tympanometry tests using an AT235 tympanometer (Interacoustics, Middelfart, Denmark). All participants' sociodemographic characteristics, additional diseases, and clinical characteristics were recorded. The two groups' cVEMP records were then compared.

Free T3, free T4, and thyroid-stimulating hormone (TSH) values in our hospital are calculated using an immunoassay analyzer (Beckman Coulter UniCel® Dxl 800 Immunoassay System, USA). These were measured as the patient group's thyroid hormones (fT3<2.6 pg/mL, fT4<0.61 ng/dL, and TSH>5.33 mIU/L).

Cervical VEMP procedure

The tests were performed by an experienced audiologist (S.S.A.) in the Kastamonu Training and Research Hospital Audiology Department. All audiological tests performed in this clinic are recorded. The VEMP test was conducted in a silent room using a Socrates device (Hedera Biomedics, Italy. The patients were placed in the supine position for the recordings, facing the contralateral side and raising their heads to ensure sufficient and continuous tension in the SCM muscle. Electromyographic activity was measured with a reference electrode sited above the upper third of the SCM muscle, an active electrode located on the suprasternal notch, and an earth electrode on the patient's forehead. The areas to which the electrodes were to be attached were cleansed beforehand. The response to monaural stimuli of the ipsilateral SCM muscle was recorded. The acoustic stimuli (tone-burst, 500 Hz, 4.3/s stimulus rate, rise=2ms, plateau=1 ms, fall=2ms) were emitted by means of ER3C insert earphones (Etymotic, USA). Stimuli commenced at 100 dBnHL for detection of the VEMP threshold. The intensity was then reduced in 10 dBnHL steps until no response was achieved at traces. The stimulus was then controlled by means of incremental 5 dBnHL rises to determine the threshold value. Ipsilateral myogenic potentials were recorded using surface electrodes without contralateral masking. The recording electrode impedance was held below 5 ohms. The first positive wave was marked as P1 and the first negative wave as N1, following which the two waves' latencies and interpeak amplitudes (IPAs) were determined and recorded. VEMP response was regarded as absent when the biphasic wave forms were not detectable and repeatable. The VEMP asymmetry ratio was calculated using the formula VEMP asymmetry (%) = 100 (Ar - Al) / (Ar + Al), and the result was recorded. Ar indicates the amplitude on the right, and Al the amplitude on the left.

Statistical analysis

Statistical analyses were conducted using Statistical Package for the Social Sciences (SPSS) version 20.0 software (IBM Corporation, New York, NY, USA). Data distribution was evaluated by means of the Shapiro Wilk test. Student's t test was applied for analysis in case of normal distribution, and the non-parametric Mann Whitney test if distribution was not normal. The study data were expressed as mean ± standard deviation. The chi-square test was employed to analyze categorical data. p values <0.05 were regarded as significant for all tests. Data concerning the presence of VEMP responses and gender were expressed as number and percentage values and were analyzed with chi-square test. VEMP findings were expressed as mean ± standard deviation and analyzed with Student's t test.

RESULTS

Thirty-one patients ranging in age between 21 and 57 years (38.5±9.7) and a control group of 26 healthy volunteers aged between 20 and 52 years (36.1±8.8) were enrolled in the study. No significant age difference was observed between the two groups (p=0.339). All members of both groups were women.

Primary hypothyroidism (fT3<2.6 pg/mL, fT4<0.61 ng/dL, and TSH>5.33 mIU/L) was present in all members of the patient group. Control group thyroid function tests were within normal limits (fT3=2.6-4.4 pg/mL, fT4=0.61-1.12 ng/dL, and TSH=0.38-5.33 mIU/L). Detailed otorhinolaryngological and audiological (pure-tone audiometry and tympanometry) tests were normal in both groups.

Normal VEMP responses are shown in Figure 1. Unilateral (Figure 2) or bilateral (Figure 3) absent VEMP responses were observed in 12 members of the patient group and in three members of the control group. Absent VEMP response rates were significantly higher among the members of the patient group (p=0.033) (Table 1).

Table 1. VEMP responses.

Clinical Variables	Patients (n) (%)	Control (n) (%)	p
Positive VEMP	19 (%61.2)	23 (%88.4)	
Bilaterally absent VEMP	4 (%12.9)	1 (%3.8)	
Unilaterally absent VEMP	8 (%25.8)	2 (%7.6)	
Total absent VEMP	12 (%38.7)	3 (%11.5)	0.033*

*: statistically significant; VEMP: vestibular evoked myogenic potential.

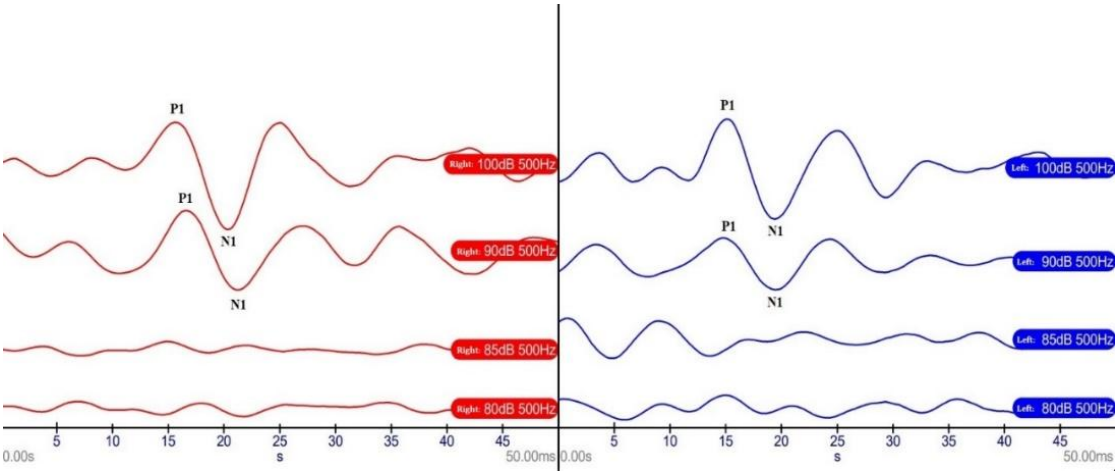


Figure 1. Normal VEMP response.

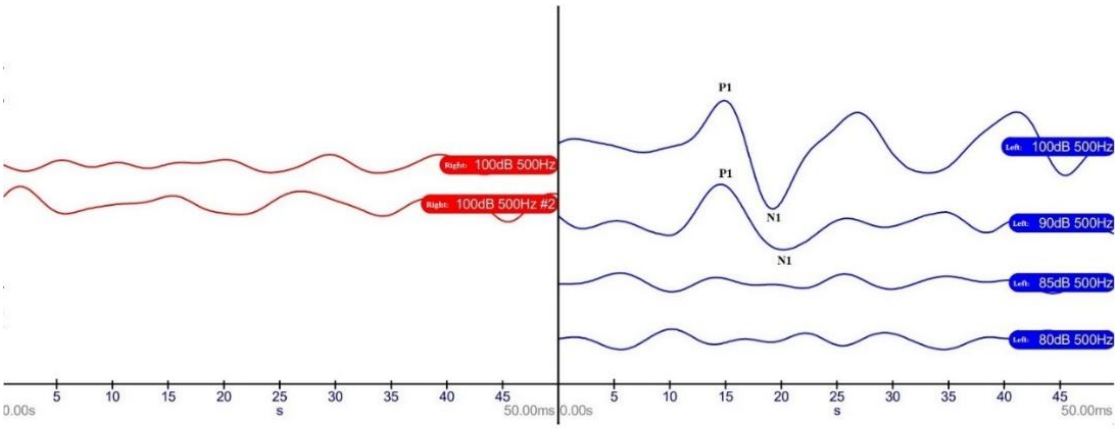


Figure 2. Unilateral (right) absent VEMP response.

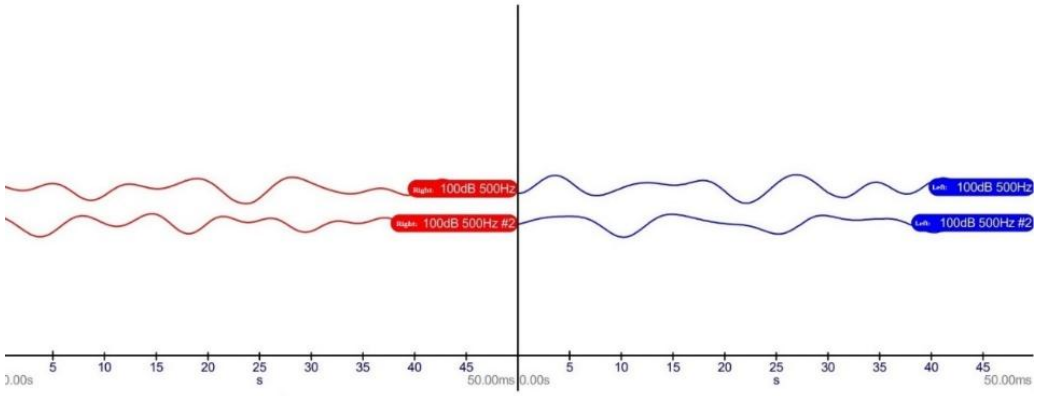


Figure 3. Bilateral absent VEMP response.

VEMP findings are summarized in Table 2. No significant differences were observed in the two groups' P1 or N1 latencies in both ears. However, IPA values in both ears were significantly lower in the patient group (p=0.026 and 0.031, respectively). No significant difference was also observed between the groups' VEMP threshold values, although asymmetry rates in both ears were significantly higher in members of the patient group (p=0.018).

Table 2. VEMP findings.

VEMP Findings	Patients	Control	p
Right P1 latency	16.46±2.1	17.81±3.4	0.123
Left P1 latency	17.12±2.1	17.83±3.2	0.372
Right N1 latency	21.79±1.9	22.6±1.9	0.178
Left N1 latency	22.09±1.9	23.14±3.3	0.195
Right IPA	138.74±48.8	181.74±42.6	0.031*
Left IPA	117.32±42.1	156.26±41.4	0.026*
Right threshold	92.27±7.5	91.66±6.3	0.769
Left threshold	93.33±8.6	92.91±6.9	0.855
Asymmetry ratio	43.20±40	24.5±25.1	0.048*

*: statistically significant; VEMP: vestibular evoked myogenic potential;
IPA: interpeak amplitude.

DISCUSSION

Thyroid hormones regulate several nervous system functions[4]. VEMP is a simple method that can be used to investigate the vestibulospinal system[12]. Since hypothyroidism causes vestibular system abnormalities, it can affect cVEMP results that provide information about the vestibulocollic reflex pathway[7]. Abnormal cVEMP records were also significantly greater among hypothyroid patients with no vestibular symptoms compared to the control population in the present study.

Absent cVEMP responses in Meniere's disease have been reported to indicate saccular dysfunction, and cVEMP has been recommended as a useful test for measuring such dysfunction[16]. Although evidence that the VEMP test can be of diagnostic value in Meniere's disease is insufficient, it has been shown to be capable of use in showing vestibular dysfunction in the disease process[15]. Another study showed that cVEMP records can be employed in screening

vestibular disorders and in the diagnosis of vestibular neuritis-related vestibulopathy[17]. The absent response rate in a previous study examining cVEMP responses in cases of vitamin B12 deficiency was twice as high in the patient group compared to the control group[9]. Similarly in the present study, unilateral or bilateral absent VEMP responses were significantly higher in the patient group. This shows that VEMP can be used to determine asymptomatic saccular pathologies in hypothyroid patients.

Studies of VEMP records in patients with benign paroxysmal positional vertigo have observed no significant differences in terms of P1 and N1 latencies between patient and control groups[13,18]. A study involving patients with multiple sclerosis reported abnormal cVEMP records in P13-N13 latencies associated with demyelination in 50% of patients[12]. Another study reported low amplitudes despite normal latencies in the VEMP test associated with saccular pathologies in 68% of patients with vestibular migraine[19]. A study of patients with vitamin B12 deficiency also reported normal cVEMP test latencies, and observed significantly higher right and left IPAs compared to a control group[9]. Studies comparing patients with vestibular migraine with healthy controls have also reported lower amplitude records at VEMP in the patient groups[20,21]. A study comparing patients with ankylosing spondylitis and a healthy control group reported no significant difference in terms of P13 and N23 wave latencies, but showed lower wave amplitudes in the patient group[10]. Similarly in the present study, both right and left ear IPAs were significantly lower in the hypothyroid patients. P1 and N1 latencies being normal in both groups may be attributable to normal and abnormal latency values being very close to one another and to a larger population being required to obtain a statistically significant outcome.

High wave amplitudes and threshold stimuli are observed in cases in which vestibular system sensitivity increases, such as the Tullio phenomenon[10]. In the present study, wave amplitudes decreased in the hypothyroid patients, while asymmetry rates were significantly higher in both ears. Similar results have been obtained with patients with vitamin B12 deficiency[9]. Our findings support the idea of a decrease in peripheral vestibular structure sensitivity in hypothyroid patients.

Due to the low number of patients with hypothyroidism, cVEMP responses could not be examined by dividing the patients into groups based on thyroid function tests. Unfortunately, no correlation could be established between hypothyroidism severity and symptom score, and this represents a limitation of the study. In addition, the results obtained by performing the cVEMP test after the patients had become euthyroid following hormone replacement therapy were not compared with those from the hypothyroid period. Another limitation of this study is that other audiovestibular tests apart from VEMP were not employed.

In conclusion, cVEMP is a rapid, simple, non-invasive, objective, and reasonably priced neurophysiological test used for evaluating the vestibular system. Our results showed that hypothyroidism affects cVEMP pathways, can result in peripheral vestibular hypofunction, and requires further investigation. VEMP recording can be employed for screening purposes in hypothyroid patients with no vestibular symptoms and can help detect subclinical vestibular hypofunction. We also believe that thyroid function tests should be checked in patients whose cVEMP response is absent or impaired. We are not able to comment on whether or not neurological dysfunction was reversible after treatment, and this might be usefully investigated in further, more extensive studies.

Author Contributions: Concept/Design : AK, FA, KT, SSA, FA, KK; Data acquisition: AK, FA, KT, SSA, FA, KK; Data analysis and interpretation: AK, FA, KT, SSA, FA, KK; Drafting manuscript: AK, FA; Critical revision of manuscript: AK, FA, KT, SSAFA, KK; Final approval and accountability: AK, FA, KT, SSA, FA, KK; Technical or material support: AK, FA, KT, SSA, FA, KK; Supervision: AK, FA, KT, SSA, FA, KK; Securing funding (if available): n/a.
Ethical Approval: Ethical approval was obtained from the Clinical Research Ethics Committee of Kastamonu University with the decision dated 28.01.2021 and numbered 2020-KAEK-143-29.
Peer-review: Externally peer-reviewed.
Conflict of Interest: The authors declare that they have no conflict of interests..
Financial Disclosure: Authors declared no financial support
Acknowledgement: We want to thank to Mr. Carl Austin Nino Rossini for his precious contribution.

REFERENCES

1. Miśkiewicz-Orczyk KA, Lisowska G, Kajdaniuk D, Wojtulek M. Can Hashimoto's thyroiditis cause vertigo? Endokrynol Pol. 2020;70:76-86.
2. Bittar RSM, Sanchez TG, Santoro PP, Medeiros IRT. O metabolismo da glicose e o ouvido interno. Arq Otorrinolaringol. 1998;2:4-8.
3. Santosh UP, Rao MS. Incidence of hypothyroidism in Meniere's disease. J Clin Diagn Res. 2016;10:1-3.
4. Gupta N, Arora M , Sharma R , Arora KS. Peripheral and central nervous system involvement in recently diagnosed cases of hypothyroidism: an

electrophysiological study. Ann Med Health Sci Res. 2016;6:261-6.
5. Parkhad SB, Palve SB, Chandrashekhar MC, Shankari P. Assessment and comparison of electrophysiological findings in thyroid dysfunction patients of Kanchipuram district. Int J Biol Med Res. 2015;6:5068-71.
6. Valcheva S, Todorov S. Dizziness systemic metabolic disorders. Int Bulletin of Otorhinolaryngol. 2015;4.
7. Santos MD, Bittar RS. Vertigo and metabolic disorders. Int Tinnitus J. 2012;17:16-20.
8. Mahadule AA, Jadhao PS, Phatak MS. Motor conduction parameters in recently diagnosed and untreated hypothyroidism. Ann Neurosci. 2015;22:6-10.
9. Özdemir D, Mehel DM, Küçüköner Ö, Ağrı İ, Yemiş T, Akgül G et al. Vestibular evoked myogenic potentials in patients with low vitamin b12 levels. Ear Nose Throat J. 2021;100:231-5.
10. Özgür A, Serdaroğlu Beyazal M, Terzi S, Coşkun ZÖ, Dursun E. Vestibular evoked myogenic potentials in patients with ankylosing spondylitis. Eur Arch Otorhinolaryngol. 2016;273:2953-7.
11. Bayram A. Vestibular evoked myogenic potentials in patients with diabetes mellitus. J Otol. 2019;14:89-93.
12. Eleftheriadou A, Deftereos SN, Zarikas V, Panagopoulos G, Sfetsos S, Karageorgiou CL et al. The diagnostic value of earlier and later components of vestibular evoked myogenic potentials (VEMP) in multiple sclerosis. J Vestib Res. 2009;19:59-66.
13. Korres S, Gkoritsa E, Giannakakou-Razelou D, Yiotakis I, Riga M, Nikolpoulos TP. Vestibular evoked myogenic potentials in patients with BPPV. Med Sci Monit. 2011;17:42-7.
14. Venhovens J, Meulstee J, Verhagen WI. Vestibular evoked myogenic potentials (VEMPs) in central neurological disorders. Clin Neurophysiol. 2016;127:40-9.
15. Fife TD, Colebatch JG, Kerber KA, Brantberg K, Strupp M, Lee H et al. Practice guideline: cervical and ocular vestibular evoked myogenic potential testing: report of the guideline development, dissemination, and implementation subcommittee of the American Academy of neurology. Neurology. 2017;89:2288-96.
16. Timmer FC, Zhou G, Guinan JJ, Kujawa SG, Herrmann BS, Rauch SD. Vestibular evoked myogenic potential (VEMP) in patients with Meniere's disease with drop attacks. Laryngoscope. 2006;116:776-9.
17. Nola G, Guastini L, Crippa B, Deiana M, Mora R, Ralli G. Vestibular evoked myogenic potential in vestibular neuritis. Eur Arch Otorhinolaryngol. 2011;268:1671-7.
18. Akkuzu G, Akkuzu B, Ozluoglu LN. Vestibular evoked myogenic potentials in benign paroxysmal positional vertigo and Meniere's disease. Eur Arch Otorhinolaryngol. 2006;263:510-7.
19. Baier B, Stieber N, Dieterich M. Vestibular-evoked myogenic potentials in vestibular migraine. J Neurol. 2009;256:1447-54.
20. Allena M, Magis D, De Pasqua V, Schoenen J, Bisdorff AR. The vestibulo-collic reflex is abnormal in migraine. Cephalalgia. 2007;27:1150-5.
21. Roceanu A, Allena M, De Pasqua V, Bisdorff A, Schoenen J. Abnormalities of the vestibulo-collic reflex are similar in migraineurs with and without vertigo. Cephalalgia. 2008;28:988-90.